CERTIFICATE

I, Futoshi HAYAKAWA, c/o KYORITSU INTERNATIONAL, 3-2-5 Meieki, Nakamura-ku, Nagoya-shi, Aichi-ken, Japan, hereby solemnly and sincerely declare:

(1) THAT I am well acquainted with the Japanese language and English language, and

(2) THAT the attached translation is a true and accurate translation into the English language of the official copy of the document in respect of an application for a Japanese Unexamined Patent Publication No. 08-092752 published in Japan on the 9th day of April 1996, and of the official certificate attached thereto.

Futoshi Hayakawa

Futoshi HAYAKAWA

Signed this 8th day of August, 2008

PATENT ABSTRACTS OF JAPAN

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[Title of the Invention]

Method of plating a polyolefin resin product

[Abstract]

[Object] To continuously and reliably form a plating layer on a resin substrate consisting essentially of polyolefin. [Constitution] A pipe body is formed through a blow molding method, and is then degreased and etched through a placon process and an etching process. The pipe body is neutralized, and then the surface of the pipe body is oxidized and reformed in an aqueous ozone solution using a surface reforming apparatus. The surface-reformed pipe body is specially neutralized using a cationic surfactant-containing solution. Subsequently, the pipe body adsorbs catalyst particles through a catalyst-providing process comprising a catalyst process and an accelerator process, and, in this catalyst-providing process, the adsorption of the catalyst particles is accelerated. Furthermore, the pipe body is electroplated and electroless-plated through a series of plating processes to form a plating layer thereon, thereby obtaining a fuel filler pipe on which the plating layer is formed. Since the surface reforming of the pipe body is conducted by bringing the pipe body into contact with the aqueous ozone solution, the surface reforming thereof is continuously conducted in the series of the

plating processes using a relatively simple apparatus.

[Claims]

[Claim 1]

A method of plating a polyolefin resin product, comprising:

forming a roughly shaped substrate of the resin product consisting essentially of polyolefin;

etching the substrate;

neutralizing the etched substrate;

bringing the neutralized substrate into contact with an aqueous ozone solution to oxidize the surface of the substrate and thus reform the surface thereof;

specially neutralizing the surface-reformed substrate using a cationic surfactant-containing special neutralizing solution;

providing a catalyst on the surface of the specially neutralized substrate; and

bringing the substrate provided with the catalyst into contact with an electroless plating solution to form an electroless plating layer on the surface of the substrate.

[Claim 2]

The method of plating a polyolefin resin product according to claim 1, further comprising:

forming an electroplating layer on the electroless plating layer formed on the substrate.

[Claim 3]

The method of plating a polyolefin resin product according to claim 1 or 2, wherein the polyolefin is polyethylene.

[Detailed description of the invention]

[0001]

[Technical field] The present invention relates to a method of plating a polyolefin resin product, and, particularly, to a method of plating a substrate consisting essentially of polyolefin having relatively low surface polarity.

[0002]

[Background art] In a conventional technology relating to this method, first, a substrate of a resin is formed, and is simultaneously plasma-treated or corona-treated to reform the surface of the substrate, and then the reformed substrate is plated to form a plating layer thereon.

[0003] However, this conventional technology is problematic in that, since the apparatuses and processes are complicated, it is difficult to conduct continuous treatment, and thus work is not efficient. Further, in this technology, the substrate, which is surface-reformed, for example, plasma-treated, is used in the following plating process. This plating process includes a degreasing process, an etching process, and the like, but is problematic in that, even when the surface of the surface is reformed, the

reforming effect thereof may be decreased by the subsequent etching process.

[0004] Here, for example, Japanese Unexamined Patent Application Publication No. Hei05-320928 discloses an electroless plating solution including copper ions, a reductant for the copper ions, a complexing agent, and a pH adjuster, to which one or more kinds of surfactants having low surface tension are added. Due to the employment of the electroless plating solution, it is possible to form an electroless plating layer on the surface of a substrate of a resin, such as a fluorine resin, even when the substrate is not surface-reformed, as described above.

[0005]

[Problems to be solved by the invention] However, the above technology can be suitably employed in fluorine resins for printed circuit boards, but is very difficult in plating a substrate consisting essentially of polyolefin, such as high density polyethylene having low polarity. That is, in a method of plating a substrate consisting essentially of polyolefin, surface-reforming processes, such as plasma treatment, corona treatment, and the like, are required, as before.

[0006] In order to solve the above problems, an object of the present invention is to provide a method of plating a polyolefin resin product, by which a plating layer can be

continuously and reliably formed on a substrate consisting essentially of polyolefin having low surface polarity using a relatively simple apparatus.

[0007]

[Means for solving the problems] In order to accomplish the object, the present invention according to claim 1 provides a method of plating a polyolefin resin product, including: forming a roughly shaped substrate of the resin product consisting essentially of polyolefin; etching the substrate; neutralizing the etched substrate; bringing the neutralized substrate into contact with an aqueous ozone solution to oxidize the surface of the substrate and thus reform the surface thereof; specially neutralizing the surface-reformed substrate using a cationic surfactant-containing special neutralizing solution; providing a catalyst on the surface of the specially neutralized substrate; and bringing the substrate provided with the catalyst into contact with an electroless plating solution to form an electroless plating layer on the surface of the substrate.

[0008] Here, the special neutralizing solution contains a cationic surfactant, for example, alkyltrimethylammonium chloride, as a main component. This cationic surfactant serves to accelerate the adsorption of a catalyst onto the surface of the substrate in the following catalyst providing process.

[0009] Further, the catalyst providing process may be conducted through a catalyst → accelerator method or a sensitizing → activation method.

[0010] In the present invention according to claim 2, the method of plating a polyolefin resin product according to claim 1 further includes: forming an electroplating layer on the electroless plating layer formed on the substrate.

[0011] In the present invention according to claim 3, the method of plating a polyolefin resin product according to claim 1 or 2 is conducted, wherein the polyolefin is polyethylene.

[0012]

[Operation] According to the present invention of claim 1, a roughly shaped substrate of the resin product consisting essentially of polyolefin is formed. In the etching process, the substrate is etched, and thus fine recesses are formed in the surface of the substrate. In the neutralizing process, the etched substrate is neutralized.

[0013] Next, in the surface-reforming process, the surface of the etched substrate is oxidized and reformed by bringing the neutralized substrate into contact with an aqueous ozone solution. In the special neutralizing process, the surface-reformed substrate is treated using a cationic surfactant-containing special neutralizing solution. In the catalyst providing process, the catalyst is provided on the surface

of the specially neutralized substrate and is adsorbed on the surface of the recesses of the substrate. Here, through the special neutralizing process, the recesses of the substrate are easily ionically bonded with the negatively charged catalyst, and thus the adsorption of the catalyst on the surface of the recesses of the substrate is accelerated. Further, in the electroless plating process, an electroless plating layer is formed on the surface of the substrate using the adsorbed catalyst as a core by bringing the substrate provided with the catalyst into contact with an electroless plating solution.

[0014] According to the present invention, the surface forming of the substrate is conducted by bringing the neutralized substrate into contact with the aqueous ozone solution. For this reason, the surface reforming process can be continuously conducted in a series of plating processes using a relatively simple apparatus.

[0015] Further, due to the surface reforming of the substrate, the surface of the substrate is oxidized, and thus a polar group is provided on the surface of the substrate, and, at the same time, a large amount of the catalyst is adsorbed on the recesses of the substrate. Therefore, the electroless plating layer is more easily formed on the substrate.

[0016] Further, according to the present invention of

claim 2, an electroplating layer is further formed on the electroless plating layer formed on the substrate. For this reason, since the total thickness of the plating layer is increased, the substrate is strengthened. Further, when desired, the appearance of the substrate is improved.

[0017] Further, according to the present invention of claim 3, a plating layer can be easily and reliably formed even though polyethylene, which is difficult to use to form a plating layer, is used as a main component of a substrate.

[0018]

[Embodiment] Hereinafter, a preferred embodiment of the present invention, in which a fuel filler pipe, which is a part of an automobile, is embodied as a resin product, will be described in detail with reference to the accompanying drawings.

[0019] FIG. 2 is a perspective view showing a fuel filler pipe 1 as a resin product according to an embodiment of the present invention, and FIG. 3 is a schematic sectional view showing a part of the fuel filler pipe 1. The fuel filler pipe 1 is used to connect a fuel filler opening to a fuel tank therethrough. The fuel filler pipe 1 includes a pipe body 2, serving as a substrate, and a plating layer 3 provided on the outer circumference of the pipe body 2.

[0020] The pipe body 2 is formed using high density polyethylene (HDPE) as a main material through a commonly

known blow molding method. Further, the pipe body 2 includes a tubular body 4 for introducing gasoline supplied from a fuel filler opening into a fuel tank, and a return unit 5 for returning some of the gasoline upstream. Further, the plating layer 3 includes an electroless plating layer and an electroplating layer. The electroless plating layer is formed of nickel and has a thickness of about 0.3 ~ 1 ㎛. The electroplating layer is formed to have a thickness of about 20 ~ 30 ㎛, and examples of the electroplating layer may include a strike plating layer, which is made of nickel, a copper plating layer, a semi-lustrous nickel plating layer, a lustrous nickel plating layer, and a chromium plating layer (none of these layers are shown).

[0021] Further, the tubular body 4 is provided with a metallic retainer 6 at the end thereof located near the fuel filler opening. Further, flanges 7 for installing the fuel filler pipe 1 in a vehicle body are integrally formed at the center of the tubular body 4.

[0022] Next, a surface reforming apparatus, which can be used when the plating layer 3 is formed on the fuel filler pipe 1, will be described. As shown in FIG. 4, the surface reforming apparatus 11 includes an ozone generator 12, a heater 13, a spray nozzle 14, a drain 15, a hose for connecting these members, and the like. The ozone generator 12 serves to convert oxygen into ozone and to dissolve ozone

in water. Further, the ozone generator 12 is provided therein with a pump (not shown), and thus an aqueous ozone solution can be pumped to the heater 13. Further, the heater 13 serves to heat the aqueous ozone solution to a predetermined temperature.

[0023] Furthermore, the spray nozzle 14 provided at the distal end of the hose serves to spray the heated aqueous ozone solution transferred from the heater 13 onto the pipe body 2. Here, provided that the spray pressure at the time of spraying the aqueous ozone solution onto the pipe body 2 is A (kPa) and the distance between the distal end of the spray nozzle 14 and the pipe body 2 is B (cm), it is preferred that $A \cdot B - 2 \geq 0.07$ be satisfied.

[0024] The drain 15 is provided under a conveyor for carrying the pipe body 2, and serves to store the aqueous ozone solution which has contacted the pipe body 2. The aqueous ozone solution stored in this drain returns to the ozone generator 12 through a connection pipe 16 at a predetermined flow rate.

[0025] FIG. 5 shows the relationship between water temperature and ozone solubility coefficient. That is, since ozone is difficult to dissolve in water as the water temperature is increased, ozone is easily decomposed with the increase in the water temperature. Conversely, it is generally known that the reaction rate (surface reforming

rate) is increased as the water temperature is increased. Therefore, it is preferred that the temperature control using the heater 13 be suitably conducted such that the concentration of ozone and the temperature of the aqueous ozone solution are increased. Specifically, it is preferred that the temperature of the aqueous ozone solution be 65 ~ 85℃. Further, it is preferred that the pH of the aqueous ozone solution be 7 or less. The reason why the pH of the aqueous ozone solution is 7 or less is that ozone included in the aqueous ozone solution is difficult to decompose under an acidic condition, and thus the concentration of ozone can be increased.

[0026] Further, the pipe body 2, which has been surface-reformed in the surface forming apparatus 11, is provide in the following catalyst providing process. Hereinafter, a method of manufacturing the fuel filler pipe 1 will be described with reference to FIG. 1, which is a block diagram showing a plating method according to an embodiment of the present invention.

[0027] First, the pipe body 2 is formed through a commonly known blow molding method. Subsequently, the pipe body 2 is provided in a placon process. That is, the pipe body 2 is immersed into an aqueous solution of 60℃ including 80g/l of sulfuric acid and 10g/l of placon for 125 seconds. Through this treatment, grease is removed from the surface of the

pipe body 2, and thus foreign materials adhered to the surface of the pipe body 2 are removed therefrom.

[0028] Subsequently, the pipe body 2, having undergone the placon process, is provided in an etching process. That is, the pipe body 2 is immersed into an aqueous solution of 65℃ including 380g/l of sulfuric acid, 420g/l of hexavalent chrome and 40g/l of trivalent chrome for 604 seconds. Through this treatment, the pipe body 2 is etched, and thus a plurality of fine recesses is formed in the surface thereof.

[0029] Subsequently, the pipe body 2, having undergone the etching process, is provided in a neutralizing process. That is, the pipe body 2 is immersed into an aqueous solution including 60ml of hydrochloric acid, 8ml of CR-200 (chromium waste liquid treatment agent) and 2g/l of hydrazine sulfate at room temperature for 60 seconds. Through this treatment, the acid adhered to the surface of the pipe body 2 is neutralized.

[0030] Subsequently, the surface of the pipe body 2 is reformed using the surface forming apparatus 11. That is, the pipe body 2 moves toward the right as seen in FIG. 4, and is then introduced into the surface forming apparatus 11. At this time, the pipe body 2 is sprayed with an aqueous ozone solution, and thus the surface of the pipe body 2 is oxidized and polarized due to the oxidizability of ozone

remaining in the aqueous ozone solution. At this time, regardless of the shape of the pipe body 2 (a typical pipe shape in the embodiment of the present invention), the aqueous ozone solution can be reliably sprayed onto the entire surface of the pipe body 2. For this reason, the entire surface of the pipe body 2 is uniformly oxidized, and thus the pipe body 2 is subjected to almost no spotting. Further, in order to oxidize the surface of the pipe body 2 more uniformly, the pipe body 2 is rotated using a rotation apparatus (not shown), and thus the aqueous ozone solution can be uniformly sprayed over the entire surface of the pipe body 2.

[0031] Subsequently, the surface-reformed pipe body 2 is provided in a special neutralizing process. That is, the pipe body 2, having undergone the surface reforming process, is immersed into an aqueous solution of 50℃ including 30 ml/l of a cationic surfactant (alkyltrimethylammonium chloride in the embodiment of the present invention) and 30ml/l of B-200 (surface conditioner) for 242 seconds. Through this treatment, the pipe body 2 is further neutralized, and, at the same time, the adsorption of a catalyst is accelerated in the following catalyst providing process.

[0032] Subsequently, the pipe body 2, having undergone the special neutralizing process, is provided in a catalyst

providing process. In the embodiment of the present invention, the catalyst providing process includes a catalyst process and an accelerator process. That is, in the catalyst process, the pipe body 2, having undergone the special neutralizing process, is immersed into an aqueous solution of 34℃ including 180 ml/l of sulfuric acid and 30ml/l of Catalyst-C (catalyst providing agent) for 215 seconds. Through this treatment, a palladium-tin (Pd-Sn) complex compound is adsorbed on the surface of the pipe body 2, particularly the recesses formed therein, by etching the surface of the pipe body 2.

[0033] Further, in the accelerator process, this pipe body 2 is immersed into an aqueous solution at 45℃ including 100 ml/l of sulfuric acid, 2 g/l of hydrazine sulfate and 0.5 g/l of Accelerator-X (activation accelerator) for 208 seconds. Through this treatment, tin (Sn) is removed from the palladium-tin (Pd-Sn) complex compound, and palladium (Pd) is metalized into a catalyst core.

[0034] Subsequently, the pipe body 2, having undergone the catalyst providing process, is subjected to an electroless plating (electroless nickel plating) process. That is, the pipe body 2 is immersed into an aqueous solution of 33℃ including 6g/l of nickel, 18g/l of sodium hypophosphite, 60g/l of sodium phosphite and 30g/l of nickel sulfate for 553 seconds. Through this treatment, an electroless nickel

plating layer is formed.

[0035] Subsequently, the pipe body 2, having undergone the electroless plating process, is subjected to an electro plating process. Here, various plating solutions used to form various metal electroplating layers are described. First, a plating solution for forming a strike plating layer, which is the lowermost layer of an electroplating layer, includes 30g/l of nickel chloride and 30g/l of boric acid. Further, a plating solution for forming a copper plating layer includes 200 g/l of copper sulfate, 50 g/l of sulfuric acid, 0.01 g/l of hydrochloric acid and a slight amount of a gloss agent. Further, a plating solution for forming a semi-lustrous nickel plating layer includes 280 g/l of nickel sulfate, 45 g/l of nickel chloride, 40 g/l of boric acid and a slight amount of a gloss agent. Furthermore, a plating solution for forming a lustrous nickel plating layer includes 240 g/l of nickel sulfate, 45 g/l of nickel chloride, 30 g/l of boric acid and a slight amount of a gloss agent. In addition, a plating solution for forming a chromium plating layer includes 250 g/l of anhydrous chromic acid, 10 g/l of sodium silicofluoride and 1 g/l of sulfuric acid.

[0036] Subsequently, the pipe body 2 on which the electroless plating layer is formed is sequentially immersed into these plating solutions, and, at the same time,

electricity is conducted therethrough for a predetermined time in each process. Through this treatment, an electroplating layer sequentially including a strike plating layer, a copper plating layer, a semi-lustrous nickel plating layer, a lustrous nickel plating layer and a chromium plating layer from bottom to top is formed, thus forming a plating layer 3 including an electroless plating layer and an electroplating layer. Thereafter, the plating layer 3 is washed, and is then applied on the surface of the pipe body 2, thereby manufacturing a fuel filler pipe 1.

[0037] As described above, in the embodiment of the present invention, the surface reforming of the pipe body 2 is conducted by bringing the neutralized pipe body 2 into contact with the aqueous ozone solution. For this reason, the surface forming process can be continuously performed in a series of plating processes using a relatively simple surface forming apparatus 2. As a result, production costs can be remarkably decreased, and workability can also be greatly improved.

[0038] Further, through this surface forming process, the surface of the pipe body 2 is oxidized, and thus a polar group is provided on the surface thereof. Furthermore, through the special neutralizing process, a large amount of a catalyst can be adsorbed on the surface of the recesses of the surface of the pipe body 2. Accordingly, an electroless

plating layer can be more easily formed in the electroless plating process, and thus the plating layer 3 including the electroless plating layer and the electroplating layer formed in the electroplating process can also be easily and reliably formed. As a result, the plating layer 3 can be easily and reliably formed even on a pipe body 2 made of polyethylene (including high density polyethylene (HDPE)), which is difficult to plate.

[0039] Further, in the embodiment of the present invention, since an electroplating layer is formed on an electroless plating layer, the plating layer 3, including the electroless plating layer and the electroplating layer, becomes thicker, more compact, and stronger. Accordingly, products requiring high gas barrier properties, such as a fuel filler pipe 1 of the embodiment of the present invention, can reliably prevent the permeation of fuel, such as gasoline.

[0040] In order to verify the above effects, a test for measuring the amount of permeated fuel was conducted. In the test, an apparatus for measuring the amount of permeated fuel shown in FIG. 6 was used. The apparatus 21 for measuring the amount of permeated fuel includes a cup 22 having flanges 22a and a porous plate 23. A test piece 24 (for example, a flat plate piece of a fuel filler pipe 1 of the embodiment of the present invention) is fastened by

bolts 25 and nuts 26 in a state in which it is interposed between the cup 22 and the porous plate 23. The cup 22 is filled with fuel (a mixture of gasoline containing 10% of MTBE and ethanol, a mixing ratio of gasoline to ethanol of 9:1). The amounts of fuel permeating the test piece 24 per unit area for a predetermined time (example, 1 day) were each measured.

[0041] The results thereof are shown in FIG. 7. In FIG. 7, PE is polyethylene, FKM is a fluorine-contained rubber, and a sealer is HDPE, in which nylon is oriented in a leaf disc shape. As shown in FIG. 7, the amount of fuel permeating the test piece (HDPE substrate + plating layer) of the embodiment of the present invention was 「0」. From FIG. 7, it can be seen that, according to a plating method of the present invention, a plating layer 3 can be reliably formed, and simultaneously, the plating layer 3 can reliably prevent the permeation of fuel.

[0042] Moreover, in the surface reforming process of the embodiment of the present invention, since an aqueous ozone solution is brought into contact with the surface of the pipe body 2 in a spray shape, the amount of ozone coming into contact with the surface of the pipe body 2 per hour is relatively large. For this reason, a process of bringing the aqueous ozone solution into contact with the surface of the pipe body 2 is performed for an extremely short time

compared to when a molded resin product is immersed into the aqueous ozone solution. Accordingly, in the embodiment of the present invention, even when the surface reforming process is performed for a short time, a good plating layer can be obtained (the plating layer 3 is securely formed on the surface of the pipe body 2). As a result, productivity can be remarkably improved.

[0043] Meanwhile, the present invention is not limited to the above embodiment, and may be configured as follows.

(1) In the above embodiment of the present invention, a fuel filler pipe 1 is employed as a resin product, but other resin products, for example, automobile interior and exterior parts, such as a front desk grill, a door mirror bracket, a mark plate, and the like, may be employed.

[0044] Further, even when a dual filler pipe 1 is employed, the shape thereof is not limited to the embodiment of the present invention. For example, the fuel filler pipe 1 may not include a return unit 5, retainer 6, flanges 7, and the like.

[0045] (2) In the embodiment of the present invention, among polyolefins, HDPE is used as a main material. However, even if other polyolefins, such as general polyolefin, low density polyethylene (LDPE), polypropylene, and the like, are used as the main material, this does not depart from the spirit and scope of the present invention.

[0046] (3) In the embodiment of the present invention, the pipe body 2 is formed through a blow molding method, but may be formed through other methods. (4) In the embodiment of the present invention, the plating layer 3 includes an electroless plating layer and an electroplating layer, but the plating layer may be obviated. That is, as long as an electroless plating layer can sufficiently exhibit its functions alone, the plating layer 3 may include only the electroless plating layer.

[0047] Further, the composition and thickness of each of the plating layers and the composition of each of the plating solutions are not limited to the embodiment of the present invention. Therefore, they may be changed depending on the purpose and use thereof.

[0048] (5) In the embodiment of the present invention, in the surface reforming process, the surface of the pipe body 2 is brought into contact with an aqueous ozone solution in a spray shape, but may be brought into contact with the aqueous ozone solution using other methods. For example, the surface of the pipe body 2 may be brought into contact with the aqueous ozone solution in the form of raining drop, and may be immersed into a container filled with the aqueous ozone solution.

[0049] (6) In the embodiment of the present invention, the pipe body 2 is provided in the placon process after it is

molded, but the placon process need not be conducted. (7) In the embodiment of the present invention, alkyltrimethylammonium chloride is chiefly used as a cationic surfactant, but, in addition to this, polyoxyethylene alkylamine, alkyldimethylbenzylammonium chloride, or the like may be suitably used as the cationic surfactant.

[0050] (8) In the embodiment of the present invention, the treatment temperature, time and chemicals in each of the processes are not limited to those of the embodiment of the present invention, and may be changed depending on the circumstances.

[0051] (9) In the embodiment of the present invention, the catalyst providing process includes a catalyst process and an accelerator process, but may also include a sensitizing process and an activation process.

[0052] (10) In the embodiment of the present invention, in some processes, the pipe body 2 is carried by a conveyor, but may alternatively be carried by a hanger employed in a series of plating processes.

[0053] The technical ideas that can be understood from the embodiment of the present invention, which are not described in the claims, are described below, along with the advantages thereof. (a) The method of plating a polyolefin resin product according to any one of claims 1 to 3, wherein,

in the surface reforming process, the neutralized substrate is brought into contact with the aqueous ozone solution in a spray form. Therefore, the substrate can be sufficiently surface-reformed in a short time, and the formation of a plating layer can be reliably accelerated.

[0054]

[Advantages] As described above, the method of plating a polyolefin resin product of the present invention is advantageous in that, when a substrate consisting essentially of polyolefin, having low surface polarity, is plated, a plating layer can be continuously and reliably formed on the substrate using a relatively simple apparatus.

[Brief description of the drawings]

FIG. 1 is a block diagram showing a plating method according to an embodiment of the present invention;

FIG. 2 is a perspective view showing a fuel filler pipe;

FIG. 3 is a schematic sectional view showing a part of a fuel filler pipe;

FIG. 4 is a schematic view showing a surface reforming apparatus according to an embodiment of the present invention;

FIG. 5 is a graph showing the relationship between water temperature and ozone solubility coefficient;

FIG. 6 is a sectional view showing an apparatus for

measuring the amount of permeated fuel; and

FIG. 7 is a graph showing the relationship between the amounts of permeated fuel depending on test pieces.

[Reference Numerals]

1... FUEL FILLER PIPE AS RESIN PRODUCT

2...PIPE BODY AS SUBSTRATE

3...PLATING LAYER

FIG. 1

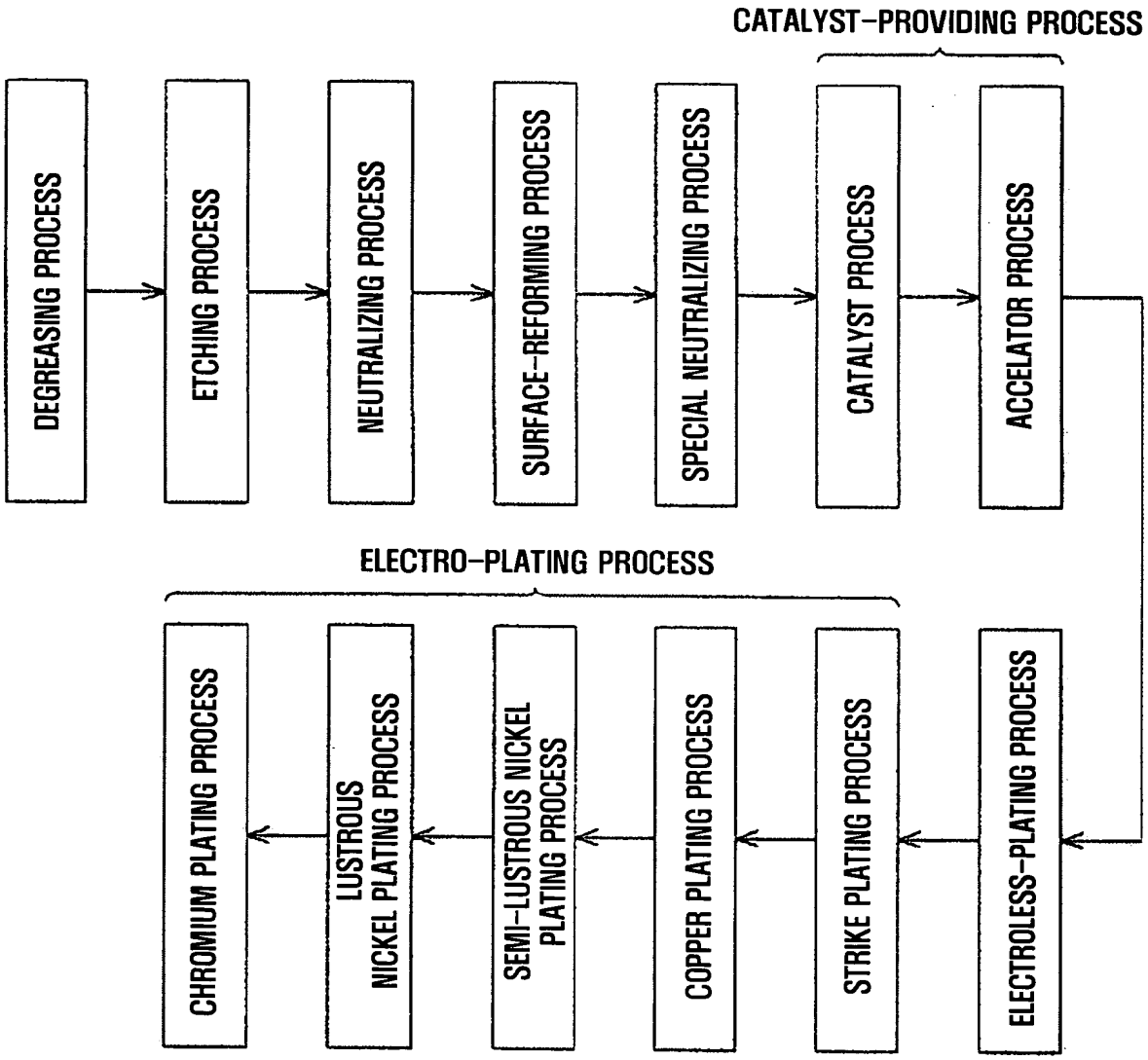

CATALYST-PROVIDING PROCESS
DEGREASING PROCESS
ETCHING PROCESS
NEUTRALIZING PROCESS
SURFACE-REFORMING PROCESS
SPECIAL NEUTRALIZING PROCESS
CATALYST PROCESS
ACCELATOR PROCESS
ELECTRO-PLATING PROCESS
CHROMIUM PLATING PROCESS
LUSTROUS NICKEL PLATING PROCESS
SEMI-LUSTROUS NICKEL PLATING PROCESS
COPPER PLATING PROCESS
STRIKE PLATING PROCESS
ELECTROLESS-PLATING PROCESS

FIG. 2

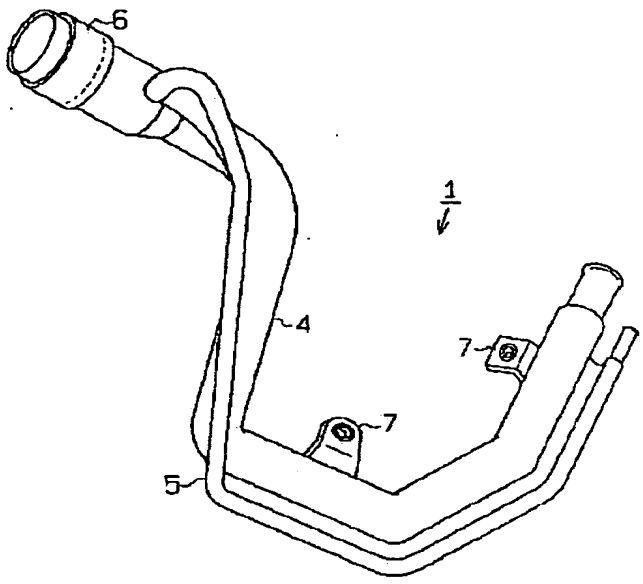


FIG. 3

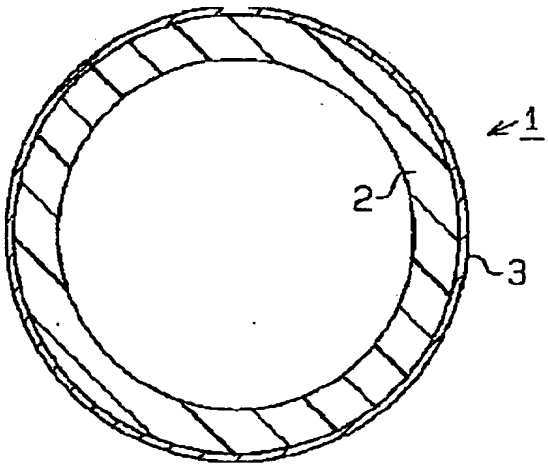


FIG. 4

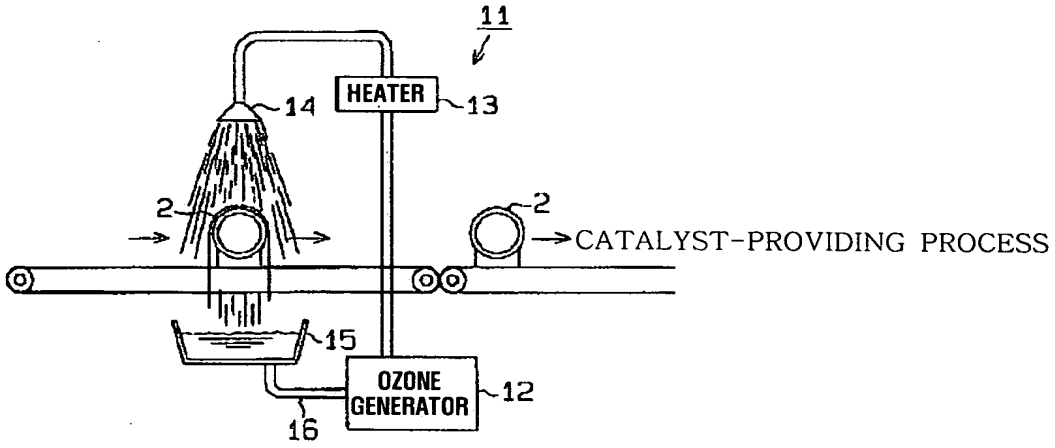
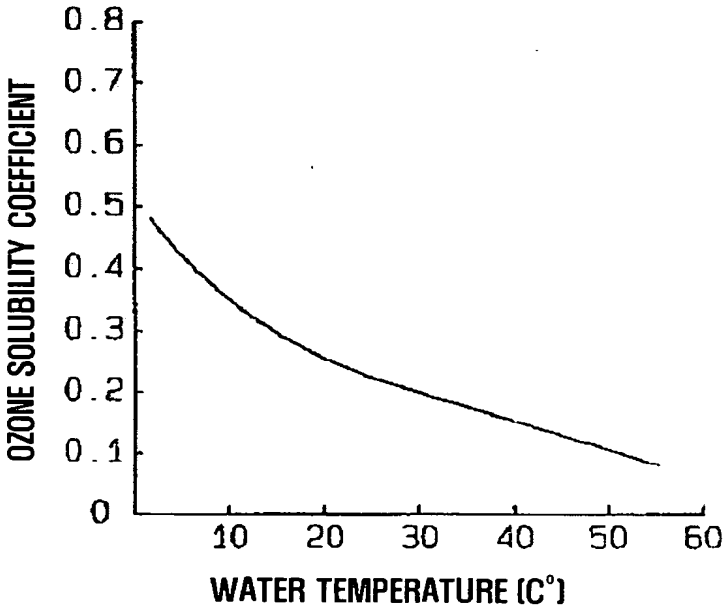

11
HEATER
13
14
2
2
CATALYST-PROVIDING PROCESS
15
OZONE GENERATOR
12
16

FIG. 5


OZONE SOLUBILITY COEFFICIENT
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
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20
30
40
50
60
WATER TEMPERATURE (C°)

FIG. 6

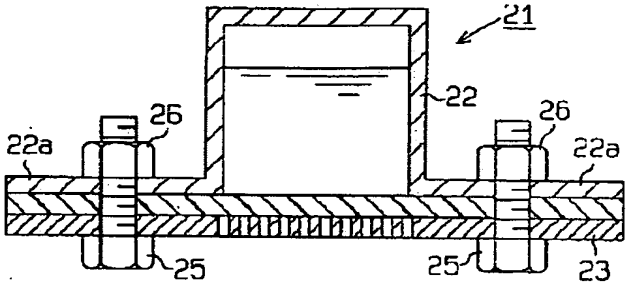
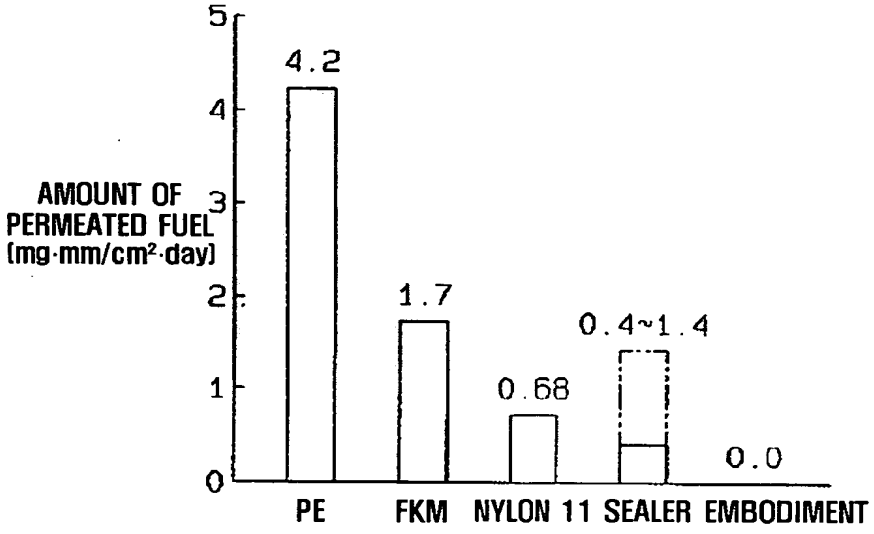

21
22
26
26
22a
22a
25
25
23

FIG. 7


AMOUNT OF PERMEATED FUEL (mg·mm/cm²·day)
5
4
3
2
1
0
4.2
1.7
0.68
0.4~1.4
0.0
PE
FKM
NYLON 11
SEALER EMBODIMENT